the displaced water; and the rise in the latitude of Edinburgh would be 312 feet. The fall of level on the southern hemisphere would, of course, be equal to the rise of level on the northern. According to the method advanced by Mr. D. D. Heath (Phil. Mag. for April, 1866, p. 323), the rise of level at the North Pole would be about 650 feet. Archdeacon Pratt's method (Phil. Mag. for March, 1866, p. 172) makes the rise still greater; while according to Rev. O. Fisher's method ("Reader," 10th Feb. 1866) the rise would be no less than 2000 feet. There is, however, another circumstance which must be taken into account, which will give an additional rise of upwards of one hundred feet.

(*To be continued.*)

IV.—On the Geology of the Nottingham District.[1]

By the Rev. A. Irving, B.A., B.Sc., F.G.S.,
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A GLANCE at the map shows that within a short distance of the town of Nottingham there are Coal-measures, Permian, Bunter, Keuper, and Lias rocks. A paper therefore on the district must of necessity be somewhat lengthy, but perhaps of all the greater interest as dealing with the border-land of the Palæozoic and Mesozoic epochs. The generally supposed unconformability between the Permian and Triassic rocks does not appear to exist in this area; while that between the Permian and the Coal-measures is very considerable.

(1). *Coal-measures.*—There are seven seams of coal at present worth working in this coal-field, with many more of inferior quality. The uppermost of the seven is the "Top-hard" or "Barnsley" Coal, the lowest the Kilburn Coal. Below the latter are the comparatively worthless strata known as the "Ganister Beds," which are found on the Derbyshire side of the coal-field, resting upon the Millstone-grit. The enormous unconformability between the Coal-measures and the Permian is shown by the fact that at the Shire-oak Colliery, near Worksop, 1300 feet of Coal-measures had to be penetrated in sinking the shaft before the Top-hard seam was reached; while at Strelley, rather more than twenty miles to the south, the Magnesian Limestone is seen, as the author is informed by Mr. G. Fowler, C.E., resting immediately upon the same seam. This so far corroborates the opinion of Mr. Howell, that the axis of the elongated basin in which these Coal-measures probably lie is along a line passing north-west and south-east through Bradford and Worksop. At the same time it removes the Permian rocks, by an enormous space in time, from the Carboniferous Period. This removal is further shown by the examination of a fault at the Cinder Hill Colliery, at Basford. This fault has been found, by actual measurement in the pit, to have effected a displacement in the Coal-measures to the extent of 88 yards of *throw*, while the same fault, passing upwards through the Permian and Bunter rocks,

[1] Being the substance of a paper read before the Geologists' Association, March 6th.—Prof. Morris, F.G.S., Vice-President, in the Chair.

has affected *both these series equally*, but to the extent of only about thirty feet of displacement. The whole fault is therefore the result of *two separate movements;* the first and greatest, Pre-permian; the second subsequent to the deposition of the Lower Bunter.

The recent high prices of coal and the prosperous condition of Nottingham trade have led to many borings for that mineral in the neighbourhood; *e.g.* at Chilwell, and at Highfield, both in the Trent Valley near Nottingham, and at Swinderby near Newark. At Highfield, Coal-measures were entered after passing through nearly 100 ft. of Bunter rock; and Coal has been cut at a depth of 254 ft. That at Swinderby is perhaps the most interesting boring going on anywhere; since, if scientifically conducted, it will throw great light upon the south-easterly extension of the Coal-basin, (which is considered by high authorities to include Newark and Lincoln,) and inferentially upon the physical geography of Carboniferous times—the extension of the old land surface believed to have occupied great part of the present German Ocean. At the colliery of Saul Isaac, Esq., M.P., close by Nottingham, the Top-hard coal is cut at a depth of 70 yards, and the Deep-hard is worked at a depth of 270 yards. The Top-hard seam has been thrown down a distance of 95 yards on the south side of the pit, and is soon to be worked at that extra depth, on account of the great expense which is caused in the working of the Deep-hard seam, by a number of 'step'-faults with a throw of 3 to 5 yards each, on the north side of the pit. The Coal is at present largely worked in the valley of the Leen, at Hucknall, and other places; and even through the Triassic rocks at Annesley. A pit is being also sunk on the north side of Bestwood Park. In this we see a speedy realization of the anticipation, by the late Sir R. I. Murchison, of the time when a general rise in the price of coals would lead to a great extension of the working of the seams; which, as he showed in his paper before the British Association at Nottingham, in 1866, extend a long way to the eastward beneath the Permian and Triassic rocks.

(2). *The Permian.*—The great unconformability between the Coal-measures and the Permian rocks is rendered the more significant by the absence of the Lower Red Sandstone (or Rothliegende). On the other hand, there are clear signs of *continuous deposition* of the Permian and Lower Bunter rocks, as is seen by examination of the sections exposed: (1) at Cinder-hill, (*a*) in the brick-yard, (*b*) in the railway cutting now in progress through the outlier of Bunter resting upon Permian rocks a little more to the North; (2) at Kimberley. The junction of these two (so-called) formations is marked by a band of breccia, the rocks above and below this band being conformable to one another. Moreover, as we pass south, the Permian strata disappear altogether, the Bunter overlapping them and resting immediately upon the Coal-measures.

In the absence of palæontological evidence, what can we rely upon but stratigraphical data? And so far as this area is concerned, the latter seem to point to the Permian and Bunter as but portions of one great unbroken sequence of rocks with perhaps a

slight alteration of the shore-line at the horizon where the breccia occurs, deposited upon the much disturbed and denuded Coal-measures, and highly unconformable to them. If therefore the Permian must needs be assigned to the Palæozoic epoch, the Bunter, it would seem, ought to go along with it; while a boundary line drawn above the Bunter would be perhaps more natural and more analogous to the line of demarcation between the Mesozoic and Cainozoic epochs. Another way out of the difficulty would be, perhaps, to consider the Permian and Bunter as one great transition series. After a careful perusal of the valuable memoir by Prof. Hull on the *Permian and Triassic Rocks of the Midland Counties*, and thus becoming acquainted with the *meagre evidence* on which the great line of demarcation between the Bunter and Permian rocks has been drawn in the northern Permian area, the author feels compelled to attach some importance to the evidences of continuous deposition which are found in this neighbourhood.

(3). *The Bunter.*—The Lower Mottled Sandstone does not attain a greater known thickness than one hundred feet in the Nottingham and Derbyshire area. Some good sections of it are seen at Basford, Radford, and Lenton. At the last-named place it has been brought up by a fault of more than three hundred feet *throw* to a level with the Keuper. This fault may be observed in the lane close to Highfield; also about a mile to the west, and in the Wilford colliery, where its throw is proved by actual measurement. The "Himlack Stone" on the north side of Bramcote Hill exhibits the junction of the Lower and Middle Bunter. It is marked by unconformability, and a bed of calcareous grit and breccia forms here the basement of the Pebble Beds. This clear boundary-line is by no means general; a passage marked by the gradual appearance of pebbles and hardening of the rock is far more common in the district. This passage may be well seen in several places; as, *e.g.* on Nottingham Forest adjoining the race-course, at Basford, and in the road-cutting about a mile south of Mansfield.

The Middle Bunter is evidently a shore-formation, with thick beds of sandstone, much harder than the Red and Mottled Sandstones above and below. Intercalated bands of distinctly laminated micaceous deep-red sandstone, semi-consolidated gravels, and true conglomerates, containing an immense variety of pebbles (chiefly of quartzite), some well-rounded, others sub-angular, are its chief characteristics. The general prevalence of "oblique lamination" indicates an area of deposit subject to shifting currents, while the great quantity of sand mingled with the pebbles, as contrasted with a shingle thrown up by a rolling surf (as *e.g.* the Chesil Bank at Portland), seems to imply a shore somewhat protected from the open ocean. The cakes and lumps of red and purple marl found in the rock seem to indicate some disturbance of the Permian strata, supposing, as is probable, that they were derived from the Permian marls. The angularity of many of the contained fragments is well preserved, and they appear to have come from different sources at varying distances; even slabs of Millstone-grit and Yoredale

sandstones, distinctly angular, are to be met with imbedded in the hard sand rock. The Castle rock, which overlooks the Trent, is of this sub-formation, and most of Nottingham is built upon it. The ancient cave-dwellings, which gave the name to the town, are excavated in it. The Castle rock is traversed by a series of 'master-joints,' running in a north-westerly direction; and joints parallel to these are to be observed at intervals all along the southern face of the rock. The valleys formed by the erosion of this rock, and opening upon the Trent Valley, appear to have had their direction determined by these joints, which, as lines of weakness, must have facilitated denudation.

The Upper Red and Mottled Sandstone, which overlies the Pebble beds in some parts of the Triassic area, but is usually considered to be wholly wanting in this district, seems nevertheless to be represented by some fragmentary patches. From a description of one of these, so high an authority as Professor Hull has been led to acquiesce in this view of the author's; but most of it was denuded away in the interval between Bunter and Keuperian times.

The present Bunter country includes the old forest-lands of Sherwood. It offers great advantages for water-supply, its porosity and underlier of marl allowing it to act as a huge reservoir.

(4). *The Keuper.*—The Lower Keuper strata or "Waterstones," consisting of alternating beds of sandstones and marls, are seen, in the few sections where the junction is exposed, resting upon the eroded or denuded surface of the Bunter. Close to Nottingham this has been observed, (1) in Red Lane, (2) in a culvert now covered over on the east side of the town (by Mr. E. Wilson, F.G.S.). At both these places the junction is marked by a bed of highly calcareous breccia, and there is unconformability between the two formations. The junction is also exposed in the hill-side east of Sneinton, where there is a marly breccia; and a still more interesting example of it was to be seen a short time ago in a culvert at the foot of Blue-bell Hill, close to Nottingham. Here the junction is marked by a hard red conglomerate (1 foot thick). This is surmounted by 8 feet of Keuper sandstones, interbedded with three well-marked layers of ochreous-yellow limestone, each about 3 inches thick. May not these be homotaxial with part of the Muschelkalk? Above these the marls and ripple-marked sandstones come in. Some good sections of the Lower Keuper, showing the passage into the Upper Red Marls, may now be seen in the cuttings and tunnel of the railway in course of construction on the north-east of Nottingham. Footprints of *Cheirotherium* have been observed at Castle Donnington, and recently by the author at Colwick, near Nottingham. Rain-pittings, sun-cracks, and ripple-marks are also frequently met with. The latter are so common on the blocks of mudstone brought from beneath the Mapperley Plains as to form the rule rather than the exception.

The Upper Keuper strata are much more marly in character than the Lower. The two members of the formation may be seen side by side, where a fault intersects the face of the cliff that overhangs the

Midland Railway and faces Colwick Hall. The upper series is marked here, as elsewhere, by the comparative absence of sandstones and the abundance of veins of satin-spar or "fibrous gypsum." Here and elsewhere the author has noticed a general tendency of the direction of the long prismatic crystals towards the vertical; a phenomenon as yet unexplained so far as he is aware. Gypsum of a more amorphous character ("alabaster") is largely quarried at Chellaston and Aston (where beds occur 9 feet in thickness), at Thrumpton, and at Newark. At the last-named place the beds are about a foot in thickness, though one bed attains a thickness of three feet, with numerous thin veins ramifying in all directions, quite irrespectively of the planes of bedding of the marl. Rounded and lenticular masses of gypsum (some pure white, others of a delicate flesh-colour) are found here also, and have so contorted the strata above them as to give proof of their consolidation subsequently to the deposit of the marls. Pseudomorphs of rock-salt have been found in the uppermost beds of the marls at Newark, Colwick, Blue-bell Hill, and Carlton, in addition to the places mentioned by the Government Geological Surveyors. The author has in his possession a slab (picked up at Newark by one of his pupils) on which the pseudomorphs are interspersed with fish-scales—precursors, as it were, of the Rhætic bone-bed. The total thickness of the Keuper is little, if any, more than 200 feet.

(5). *The Rhætic Beds.* The black paper-shales were discovered by Mr. Etheridge a short time ago, at Elton, near Nottingham, on the Great Northern Branch line; and the author has found there also a portion of the 'bone-bed.'

A section of Rhætic beds was found by the author last spring outside Newark, where are seen:

	feet.
1. Black 'paper-shales' abounding along a certain horizon in *Avicula contorta* and *Pullastra arenicola*	10
2. Grey and greenish marls	15
	—25

The uppermost zone, or 'White Lias,' is not seen *in situ*, but what appear to be fragments of it are found in the soil above, and, in one place, among a mass of disturbed materials, composed of black shales, much broken up and mingled with pebbles apparently from the Bunter. This mass is probably in one sense a 'boulder-clay.'

Another section of the Rhætic has quite recently been brought to light at 'Spinney Hill' near Leicester, and noted by Mr. J. J. H. Teall, B.A., F.G.S.

(6). *The Lias.*—This formation plays but a subordinate part in the geology of the district, until we get into Leicestershire and the Vale of Belvoir. It caps the hills about Gotham and Thrumpton along the south side of the Trent, where no doubt Rhætic Beds might be discovered by digging into the flank of the hills. Belvoir Castle surmounts an escarpment of Marlstone of the Middle Lias, which abounds there, as in the Banbury district, with *Rhynchonella tetrahedra* and *Terebratula punctata.*

(7). *Drift and Alluvium.*—A great part of the former appears to have been carried down into the valley of the Trent, where

extensive gravel-pits are worked, as at Beeston and Sawley. The pebbles and small boulders found in the gravels are very similar to those found in the drift, of which some detached portions may be seen at New Basford, Lenton, Cinder Hill, and Annesley. In these instances the drift lies immediately upon the Bunter Sandstone. They are all in the Leen basin; and supposing them to be of Post-glacial age, they would seem to indicate a comparatively recent date (speaking geologically) for the present valley of that river, which is certainly formed by the erosion of the Bunter, on which the drift lies in elevated positions. The abundance of Bunter pebbles at present scattered over the Permian strata in the Leen Valley affords corroborative evidence of this former extension of the Bunter strata. The age of the Valley of the Trent is not so easily made out. From the occurrence of drift on the higher portions of ground included within its present basin, it would appear that the sculpturing of the main features of the landscape began during or before the Glacial Epoch. Great, however, as is the amount of alluvium and low-level gravel contained in the present valley, there can be little doubt that this is now the redeposited drift, since bones of recent Mammalia have been found in the river valley; notably in the sinking of the Wilford Pit, where they lay at the very bottom of the alluvial deposits, 25 feet below the surface. If, as it has been supposed, the Trent was once a tributary of the Rhine, that will only carry us back (according to Prof. Ramsay) to Miocene times. The question then arises whether the time between that and the Drift period is sufficient to allow for the denudation of the present area of Trent drainage, and the contemporaneous cutting down of the two passages through the Oolite escarpment, one of which is now occupied by the Humber, the other by the Witham at Lincoln.

NOTICES OF MEMOIRS.

I.—Mineralogical Observations in the Argentine Republic. Mineralogische Beobachtungen im Gebiete der argentinischen Republik von Alfred Stelzner. Mit chemischen Beiträgen von Max Siewert. *Mineralogische Mittheilungen*, 1873, Heft iv. pp. 219–254.

In this paper Dr. Stelzner, of Cordoba, records the results of his mineralogical studies in certain parts of the Argentine Republic. The value of the communication is much increased by the analytical work contributed by Dr. Siewert.

The Sierra of Cordoba, which stretches in a north and south direction over nearly three degrees of latitude, is formed of three parallel ridges, of which the central and most lofty, called the Sierra Alta, rises to a height of about 1200 metres above the surrounding pampas. These mountains consist essentially of crystalline slates, associated with granite and other rocks. The granite is penetrated in many places by quartz-stocks, which are interesting for the sake of the accessory minerals they carry. Although consisting mainly of quartz, they invariably contain mica and large crystals of orthoclase; and may thus represent a highly quartziferous variety of pegmatite.